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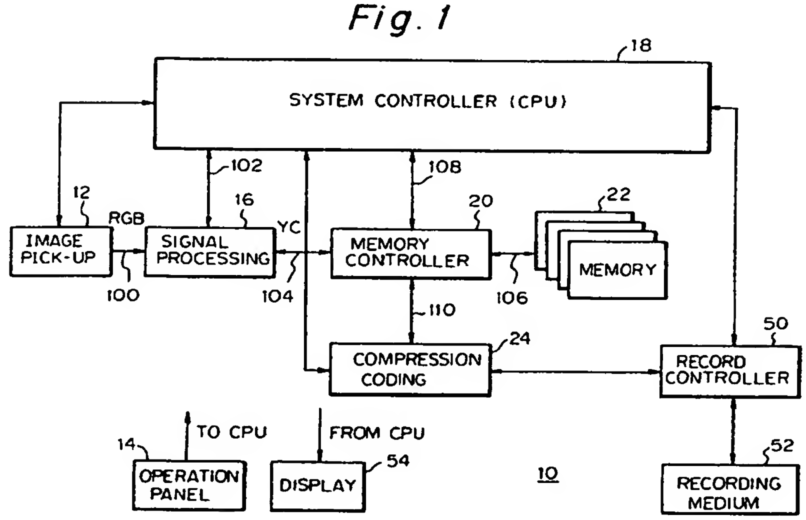
(54) **Method and apparatus for compression coding of color image data and digital camera including the same**

(57) A color image data compression coding apparatus of the present invention includes a signal processing section (16) for processing RGB (Red, Green and Blue) color image data input from an imaging device to thereby output YC (luminance and chrominance) image data consisting of luminance data and chrominance data. When a monochrome mode is set by a system controller (18), the signal processing section (16) fixes the values of chrominance data to zero. The luminance data and fixed chrominance data are written to a frame memory (22) and then sequentially read out of the memory (22) in blocks component by component. A compression coding section (24) codes the image data read out of the memory (22) by use of a JPEG (Joint Photographic Coding Expert Group) system. As for the coded data of the chrominance data, Huffman codes are assigned only to DC components and EOB (End of Block) codes. As a result, an amount of codes produced by subtracting the amount of codes allocated to the chrominance data from a desired total amount of code is entirely allocated to the luminance data as a target amount of code. After the luminance data have been coded in the target amount, the chrominance data are sequentially coded. A method for implementing the apparatus and a digital camera incorporating the apparatus are also disclosed.

Fig. 1



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When a monochrome mode for compressing and coding the image data such that the image data render a monochrome image is selected, the system controller causes the chrominance components of the image data to be fixed to a preselected value, and causes the resulting fixed chrominance components and luminance component to be compressed and coded by the compression coding circuit.

Also, in accordance with the present invention, a method of compressing and coding image data representative of a color image and including a luminance component and chrominance components begins with a step of writing processed image data output from a signal processing circuit in a storage, and reading the processed image data out of the storage in preselected blocks component by component. A compression coding circuit is caused to compress and code the processed image data read out of the storage component by component. Coded data output from the compression coding circuit are output. When a monochrome mode for compressing and coding the image data such that the image data render a monochrome image is selected, the chrominance components of the image data are fixed to a preselected value, and the resulting fixed chrominance components and the luminance component are compressed and coded by the compression coding circuit.

Further, in accordance with the present invention, a digital camera for compressing and coding image data representative of a color image and including a luminance component and chrominance components, and outputting the resulting coded image data, includes a signal processing circuit for processing the image data to thereby output processed image data. A storage stores the processed image data and allows them to be read out in preselected blocks component by component. A compression coding circuit compresses and codes the processed image data read out of the storage component by component to thereby output coded data. An outputting circuit outputs the coded data. A system controller controls a mode for compressing the image data. The system controller causes, when a monochrome mode for compressing and coding the image data such that the image data render a monochrome image is selected, the chrominance components of the image data to be fixed to a preselected value, and causing the resulting fixed chrominance components and luminance component to be compressed and coded by the compression coding circuit. When a command signal for causing the color image to be so compressed and coded as to turn out a monochrome image when reproduced is input on an operation panel, the system controller selects the monochrome mode and fixes the chrominance components of the image data to the preselected value.

An embodiment of the present invention will now be described by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a block diagram schematically showing a digital still camera embodying the present invention;

FIG. 2 is a block diagram schematically showing a compression coding section included in the embodiment in detail;

FIG. 3 shows a specific format for recording coded data output in the embodiment in a recording medium;

FIG. 4 shows a quantization table included in the format of FIG. 3 in detail;

FIG. 5 shows a Huffman table also included in the format of FIG. 3 in detail; and

FIG. 6 shows a frame header further included in the format of FIG. 3 in detail.

Referring to FIG. 1 of the drawings, a digital still camera embodying the present invention is shown and generally designated by the reference numeral 10. As shown, the camera 10 includes an image pick-up 12 for picking up a desired scene and outputting an image signal representative of the scene. The image signal is transformed to corresponding image data, subjected to compression coding, and then written to a memory card or similar recording medium, as will be described specifically later. The camera 10 compresses and codes the image data by, e.g., the standardized JPEG system mentioned earlier and is selectively operable in a color mode or a monochrome mode. The user of the camera is capable of selecting either the color mode or the monochrome mode on an operation panel 14. The portions of the camera 10 not directly relevant to the understanding of the present invention will not be shown or described. In the following description, signals are represented by the reference numerals designating connection lines on which they appear.

The image pick-up 12 is a unit for picking up a desired scene and outputting an image signal representative of the scene. In the illustrative embodiment, the image pick-up 12 includes an imaging device and a driver for driving it. When a scene incident via a lens, not shown, is focused on the light-sensitive surface of the imaging device, the imaging device outputs a corresponding electric signal. The image pick-up 12 further includes an iris mechanism, an optical zoom mechanism, and an autofocus (AF) mechanism, although not shown specifically. The lens has a macro-function for implementing, e.g., close shots and allows the user to shoot even a color or monochrome printing on which a fine text pattern or graphic pattern is recorded. The AF mechanism is implemented as a range finding and focus adjusting mechanism based on a passive system using visible rays or an active system using infrared rays. Alternatively, use may be made of a contrast detection system for executing control in accordance with the contrast of the image signal output from the imaging device. With such an AF mechanism, the illustrative embodiment is capable of outputting a more clear-cut image.

be allocated to the chrominance data Cr and Cb zero. Specifically, as shown in FIG. 2, the compression coding 24 includes a DCT/IDCT (Inverse Discrete Cosine Transform) operation 30 for executing bidimensional orthogonal transform with the block-by-block image data 110. In the illustrative embodiment, bidimensional orthogonal transform is implemented by DCT. The DCT/IDCT operation 30 arranges vertically and horizontally the DC components and AC components of DCT transform coefficients generated by bidimensional orthogonal transform. Subsequently, the operation 30 rearranges the AC components and DC components such that the DC components occupy the top left portion and are sequentially replaced by the high frequency data of the AC components toward the bottom right. The output 200 of the operation 30 is connected to a quantization/dequantization 32.

The quantization/dequantization 32 normalizes the DC components and AC components output from the DCT/IDCT operation 30, using a quantization table 34 listing quantizing steps respectively assigned to the DC components and AC components. Specifically, a code amount controller 36 feeds a control signal 202 to the quantization/dequantization 32 so as to cause it to select an adequate quantization table in accordance with, among others, the characteristic of an input image. The normalized DCT transform coefficients are arranged in blocks and then sequentially scanned zigzag, low frequency AC components being first. The transform coefficients so scanned are sequentially fed to a Huffman coding/decoding 38 via a connection line 204.

The Huffman coding/decoding 38 executes entropy coding with the block-by-block quantized data applied to its input 204. In the illustrative embodiment, the coding/decoding 38 codes the input data by assigning Huffman codes listed in a Huffman table 40 to the input data, as follows. First, the coding/decoding 38 codes an estimated value of the input DC component, i.e., a difference between the DC component value of an input block and that of the immediately preceding block. Subsequently, the coding/decoding 38 codes the AC components scanned zigzag from the low frequency side to the high frequency side. Thereafter, the coding/decoding 38 inserts an EOB (End Of Block) code after a code corresponding to the last valid component, thereby indicating the end of the block. The coding/decoding 38 sequentially performs the above processing with the luminance data Y and chrominance data Cr and Cb. The block-by-block coded data are sequentially fed from the coding/decoding 38 to an I/O (Input/Output) buffer 42 via a connection line 206. Further, in response to a control signal 208 fed from the code amount controller 36, the coding/decoding 38 determines the final valid components by cutting off the data to be coded, e.g., limits the coded data to less than a preselected length inclusive.

The code amount controller 36 controls the amount of the compressed and coded data to a total amount of codes matching with the compression coding accuracy. Specifically, the controller 36 controls the quantization/dequantization 32, Huffman coding/decoding 38 and I/O buffer 42 such that the data output from the coding/decoding 38 have less than a preselected length inclusive, e.g., a fixed length. Further, the controller 36 controls the amount of codes of the decoded data by a two-path control scheme, i.e., by calculating an activity representative of the characteristic of an image, selecting an adequate quantizing step based on the calculated activity, compressing and coding image data with the quantizing step, and again compressing the image data on the basis of the amount of resulting codes. Alternatively, the controller 36 may use a single path control scheme or any other suitable control scheme, if desired.

Assume that the system controller (CPU) 18 sends mode data indicative of the monochrome mode to the code amount controller 36. Then, the controller 36 controls the Huffman coding/decoding 38 by setting the amount of AC codes which is zero, as mentioned earlier. Specifically, the controller 36 assigns a target code amount of zero to the AC codes of the chrominance data Cr and Cb. As for the luminance data Y, the controller 36 selects as a target amount of codes a value produced by subtracting the amount of DC codes and the amount of EOB codes relating to the chrominance data Cr and Cb from the total amount of codes. The controller 36 sets such two target amounts allocated to the chrominance data and luminance data, respectively, in the Huffman coding/decoding 38.

For example, assume that the number of DC components is zero. Then, on a JPEG default Huffman table, the chrominance data Cr and Cb need two bits for each block and two bits for an EOB code, i.e., four bits multiplied by the number of blocks for all the blocks. Therefore, in the case of the 4:2:2 compression scheme using the 640 (H) x 480 (V) pixel matrix, the target amount of codes to be allocated to the chrominance data Cr and Cb is 4,800 bits (2 bits x 2,400 blocks) for each of the DC components and EOB codes, i.e., 9,600 bits in total. The illustrative embodiment adds extra sixteen bits to 9,600 bits in consideration of a difference between the actual DC difference and the initial value. As a result, the controller 36 assigns 9,616 bits in total to the entire chrominance data Cr and Cb. Assuming a compression accuracy of 2 bpp (bits per pel or pixel), then the total amount of codes corresponding to image data is 614,400 bits. Therefore, as for the luminance data Y, the controller 36 selects 604,784 bits produced by subtracting 9,626 bits allocated to the chrominance data Cr and Cb from the 614,400-bit total amount of codes as a target amount of codes.

The I/O buffer 42 is a buffer memory for temporarily storing the coded data output from the Huffman coding/decoding 38 under the control of the code amount controller 36 and then delivering them to a record controller 50, FIG. 1, connected to the output of the compression coding 24.

The record controller 50 shown in FIG. 1 controls

to image data picked up, if desired.

The operation of the camera 10 having the above construction will be described hereinafter. First, assume that the user of the camera 10 selects the color mode on the operation panel 14. Then, in response to a release command also input on the operation panel 14, the system controller 18 feeds a control signal to the image pick-up 12, commanding it to shoot a scene. On the receipt of the control signal, the image pick-up 12 controls the focus and iris and then controls the electronic shutter so as to generate an image signal representative of the scene. The image signal is subjected to tonality and color correction and then converted to RGB color image data by the signal processing 16. Further, the RGB color data are transformed to YC image data consisting of luminance data Y and chrominance data Cr and Cb and then written to the frame memory 22 under the control of the memory controller 20.

After image data representative of one frame have been written to the frame memory 22, luminance data Y included in the image data are sequentially read out in 8 x 8 pixel blocks and fed to the compression coding 24. Subsequently, chrominance data Cr and Cb also included in the above image data are sequentially read out of the frame memory 22 in blocks and also fed to the compression and coding 24. In the compressing coding 24, the DCT/IDCT operation 30 executes DCT with the luminance data Y block by block, rearranges the resulting DC components and AC components, and outputs the rearranged two kinds of components. Thereafter, the DCT/IDCT operation 30 executes DCT with the chrominance data Cr and Cb block by block, rearranges the resulting DC components and AC components, and outputs the rearranged components.

The quantization/dequantization 32 receives the DC components and AC components from the DCT/IDCT operation 30 and normalizes each of them by using a particular quantizing step stored in the quantization table. The transform coefficients of each normalized component are arranged in blocks and then scanned zigzag, the DC components being first, while being sequentially output. After the DC components, the AC components are scanned in the ascending order with respect to frequency.

The Huffman coding/decoding 38 codes each transform coefficient output from the quantization/dequantization 32 by assigning a particular Huffman code listed in the Huffman table thereto. Specifically, as for the first block of DC components belonging to each of the luminance data Y and chrominance data Cr and Cb, the coding/decoding 38 directly codes their values. As for the subsequent blocks of DC components, the coding/decoding 38 codes a difference between the value of each DC component and that of the DC component of the immediately preceding block to thereby output an estimated value. The coding/decoding 3 8 sequentially scans the AC components of each component zigzag in the ascending order with respect to frequency. At this instant, the code amount controller 36 causes the coding/decoding 38 to end coding as soon as it codes the last valid component. The coding/decoding 38 outputs the sequence of coded data of each component after adding the EOB code to the end of the sequence.

The coded data output from the Huffman coding/decoding 38 are once stored in the I/O buffer 42 and then fed to the record controller 50 connected to the compression coding 24. The record controller 50 arranges the input coded data in a format matching with the recording medium 52, and then writes them in the medium 52.

As stated above, in the color mode which is usually selected, a full-color image identical with a desired scene is recorded in the recording medium 52. The coded data stored in the medium 52 by the above procedure may be read out and reproduced by the camera 10. For example, the compression coding 24 receives via the I/O buffer 42 the coded data read out of the medium 52 by the record controller 50. In the compression coding 24, the Huffman coding/decoding 38 decodes the received coded data, and the quantization/dequantization 32 dequantizes the resulting decoded data. Subsequently, the DCT/IDCT operation 30 executes IDCT with the data output from the dequantization 32. The decoded image data output from the decoding 38 are once written to the frame memory 22 via the memory controller 20 and then fed to the display 54, so that the user can see an image represented by the above image data on the display 54.

Now, assume that the user selects the monochrome mode on the operation panel 14. Then, in response to a release command also input on the operation panel 14, an image signal output from the image pick-up 12 is fed to the signal processing 16, as during the color mode operation. The signal processing 16 executes tonality and color correction with the input image signal and coverts the corrected image signal to digital values. When the controller 18 delivers the control signal 102 commanding contour enhancement to the signal processing 16, the signal processing 16 enhances the contours of the image signal before digitizing the signal.

Further, the signal processing 16 produces luminance data Y and chrominance data Cr and Cb from the digital RGB data by calculation. The luminance data Y are directly written to the frame memory 22 via the memory controller 20. The chrominance data Cr and Cb are fixed to "128" without exception and then written to the frame memory 22 via the memory controller 20.

The luminance data Y and chrominance data Cr and Cb stored in the frame memory 22 by the above procedure are sequentially read out component by component, as during the color mode operation. A control signal indicative of the monochrome mode is fed from the system controller 18 to the compression coding 24. In response, the code amount controller 36 calculates an amount of codes to be allocated to the luminance data Y. For example, in the illustrative embodiment, the con-

or a monochrome mode. The present invention is similarly applicable to, e.g, a compression coding device having a color and a monochrome compression coding mode, or a recording device having a color mode and a monochrome mode and capable of recording image data after compressing and coding them.

While the compression of a still image has been shown and described as being implemented by the JPEG system, the present invention is applicable even to, e.g., a moving picture compression system which codes a plurality of consecutive frames at a time by compression. Further, the illustrative embodiment is advantageously applicable to a full-color image data format, e.g., Exif (Exchangable image file format).

The present invention is practicable without regard to the control over the amount of codes. For example, the present invention is applicable to a two-path code amount control system having a first and a second step. In the first step, the system calculates an activity representative of the characteristic of an image, determines a quantizing step by feeding the calculated activity forward, and compresses image data with the quantizing step. In the second step, the system corrects and updates the quantizing step on the basis of the amount of codes by feedback processing and again compresses the image data with the corrected quantizing step. In this manner, the present invention is applicable to both of the feed forward system and feedback system.

The embodiment shown and described directly compresses and codes luminance data Y. Alternatively, the signal processing 16 may be so constructed as to fix the luminance data Y to the maximum and minimum bilevel data by use of a preselected threshold, and compress the bilevel luminance data and fixed chrominance data. With this alternative configuration, it is possible to generate coded data representative of a more clear-cut bilevel image despite the color image outputting and recording system.

In summary, in accordance with the present invention, coded data having a color image format, but which will turn out a monochrome image when reproduced, are achievable with a simple constuction which changes the values of chrominance components of color image data, fixes them to a preselected value, and then executes compression coding. Because a minimum amount of codes should be allocated to the chrominance components, the remaining amount of codes can be fully allocated to a luminance component. Therefore, in a monochrome mode, high resolution coded data clearly rendering a high definition image with monotone can be output for the same amount of codes as in a color mode as an entire image. The coded data so output can be reproduced in the same manner as data representative of a usual color image, so that compatibility and general-purpose application of coded data are guaranteed. Moreover, control over the amount of codes is practicable without resorting to sophisticated processing. That is, the total amount of codes of coded data can be controlled below desired one in the same manner as when a usual color image is compressed and coded.

While the present invention has been described with reference to the particular illustrative embodiment, it is not to be restricted by this embodiment. It is to be appreciated that those skilled in the art can change or modify the embodiment without departing from the scope of the present invention, which is defined by the claims.

Claims

1. An apparatus for compressing and coding image data representative of a color image and including a luminance component and chrominance components, and outputting resulting coded image data, CHARACTERIZED BY comprising:

   a signal processing circuit (16) for processing the image data to thereby output processed image data;
   a storage (22) for storing the processed image data and allowing the processed image data to be read out in preselected blocks component by component;
   a compression coding circuit (24) for compressing and coding the processed image data read out of said storage (22) component by component to thereby output coded data;
   an outputting circuit (50) for outputting the coded data; and
   a system controller (18) for controlling a mode for compressing the image data;
   said system controller (18) causing, when a monochrome mode for compressing and coding the image data such that said image data render a monochrome image is selected, the chrominance components of the image data to be fixed to a preselected value, and causing resulting fixed chrominance components and the luminance component to be compressed and coded by said compression coding circuit (24).

2. An apparatus in accordance with claim 1, CHARACTERIZED IN THAT said signal processing circuit (16) transforms an RGB color image signal input thereto to the image data including the luminance component and the chrominance components, and fixes the chrominance components to the preselected value when the monochrome mode is selected.

3. An apparatus in accordance with claim 2, CHARACTERIZED BY further comprising a signal generating circuit (12) for generating the RGB color image signal.

4. An apparatus in accordance with claim 3, CHAR-

(i) assigning preselected codes to the normalized transform coefficients.

16. A method in accordance with claim 15, CHARACTERIZED IN THAT step (h) comprises (j) quantizing, among the transform coefficients read out of said storage (22) and subjected to orthogonal transform, AC components of the chrominance components to zero.

17. A method in accordance with claim 15 or 16, CHARACTERIZED BY further comprising (k) limiting the data to be compressed and coded to no more than a preselected length.

18. A method in accordance with claim 17, CHARACTERIZED IN THAT step (k) comprises (1) subtracting an amount of codes which the fixed chrominance components will have when compressed and coded from a total amount of codes having the preselected length, setting a resulting difference as a target amount of codes to be allocated to the luminance component, and limiting the amount of codes of the luminance component to no more than the target amount of codes.

19. A digital camera for compressing and coding image data representative of a color image and including a luminance component and chrominance components, and outputting resulting coded image data, CHARACTERIZED BY comprising:

a signal processing circuit (16) for processing the image data to thereby output processed image data;
a storage (22) for storing the processed image data and allowing the processed image data to be read out in preselected blocks component by component;
a compression coding circuit (24) for compressing and coding the processed image data read out of said storage (22) component by component to thereby output coded data;
an outputting circuit (50) for outputting the coded data; and
a system controller (18) for controlling a mode for compressing the image data;
said system controller (18) causing, when a monochrome mode for compressing and coding the image data such that the image data render a monochrome image is selected, the chrominance components of the image data to be fixed to a preselected value, and causing resulting fixed chrominance components and the luminance component to be compressed and coded by said compression coding circuit (24);

wherein when a command signal for causing the color image to be so compressed and coded as to turn out a monochrome image when reproduced is input on an operation panel, said system controller (18) selects the monochrome mode, and fixes the chrominance components of the image data to the preselected value.

20. A camera in accordance with claim 19, CHARACTERIZED IN THAT said signal processing circuit (16) transforms an RGB color image signal input thereto to the image data including the luminance component and the chrominance components, and fixes the chrominance components to the preselected value when the monochrome mode is selected.

21. A camera in accordance with claim 20, CHARACTERIZED BY further comprising a signal generating circuit (12) for generating the RGB color image signal.

22. A camera in accordance with claim 21, CHARACTERIZED IN THAT said signal generating circuit (12) includes an imaging device for shooting a scene and generating an image signal representative of the scene, said imaging device comprising an RGB color filter arranged on a light-sensitive surface thereof.

23. A camera in accordance with any of claims 19 to 22, CHARACTERIZED IN THAT said outputting circuit (50) includes a recording device for recording the coded data output from said compression coding circuit (24) in a recording medium (52), the coded data being recorded in the recording medium (52) in a preselected format.

24. A camera in accordance with claim 23, CHARACTERIZED IN THAT the recording medium (52) comprises a memory card having a semiconductor memory therein, said outputting circuit writing the coded data in the memory card.

25. A camera in accordance with any of claims 19 to 24, CHARACTERIZED IN THAT said compression coding circuit (24) comprises:

an orthogonal transforming circuit (30) for executing orthogonal transform with the image data read out of said storage (22) to thereby output corresponding transform coefficients;
a quantizing circuit (32) for normalizing the transform coefficients to thereby output normalized transform coefficients; and
a coding circuit (38) for assigning preselected codes to the normalized transform coefficients.

26. A camera in accordance with claim 25, CHARACTERIZED IN THAT said quantizing circuit (32)

Fig. 1

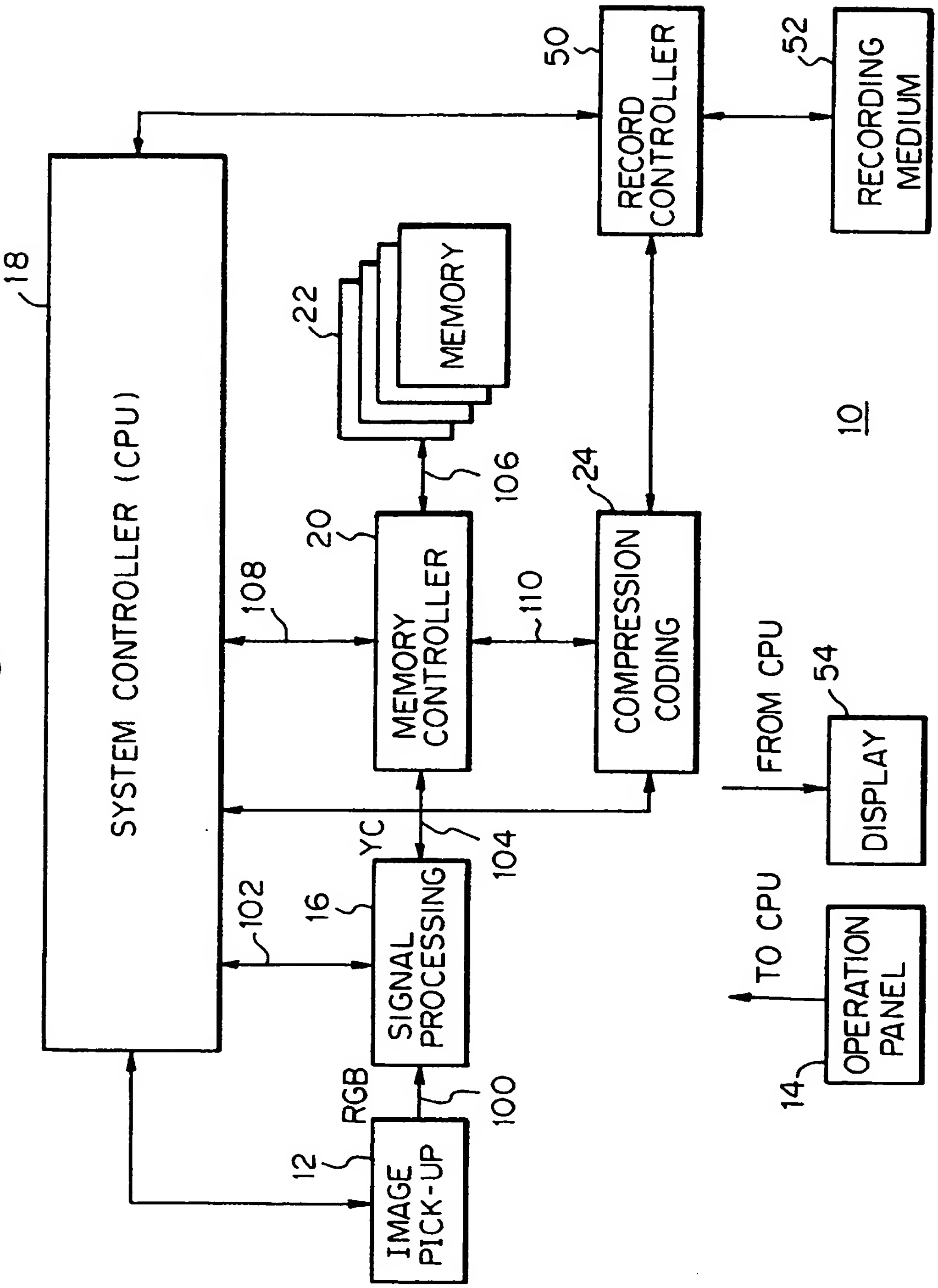
SYSTEM CONTROLLER (CPU)
18
IMAGE PICK-UP
12
RGB
100
SIGNAL PROCESSING
16
102
YC
104
MEMORY CONTROLLER
20
108
110
106
MEMORY
22
COMPRESSION CODING
24
RECORD CONTROLLER
50
RECORDING MEDIUM
52
10
FROM CPU
DISPLAY
54
TO CPU
OPERATION PANEL
14

Fig. 3

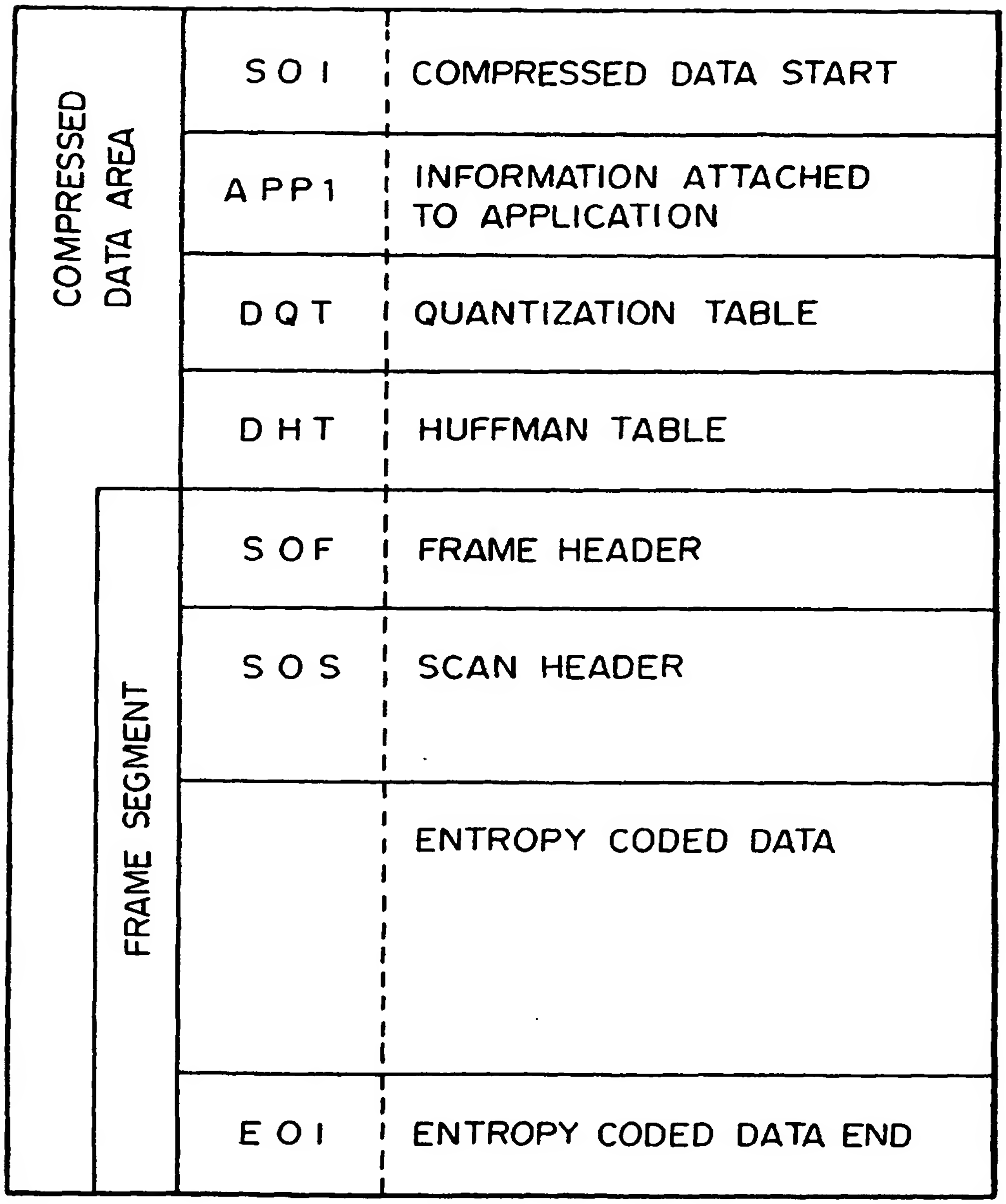
COMPRESSED DATA AREA
FRAME SEGMENT
SOI
COMPRESSED DATA START
APP1
INFORMATION ATTACHED TO APPLICATION
DQT
QUANTIZATION TABLE
DHT
HUFFMAN TABLE
SOF
FRAME HEADER
SOS
SCAN HEADER
ENTROPY CODED DATA
EOI
ENTROPY CODED DATA END

Fig. 5

ADDRESS	CODE	CONTENT
+000	FF	MARKER PREFIX
+001	C4	DHT
+002	01 A2	FIELD LENGTH 2+(1+16+12+1+16+162)x2 = 418B
+004	00	TABLE NO. Y-DC : 00
+005	:	DHT PARAMETER
+033	10	TABLE NO. Y-AC : 10
+034	:	DHT PARAMETER
+212	01	TABLE NO. C-DC : 01
+213	:	DHT PARAMETER
+241	11	TABLE NO. C-AC : 11
+242	:	DHT PARAMETER

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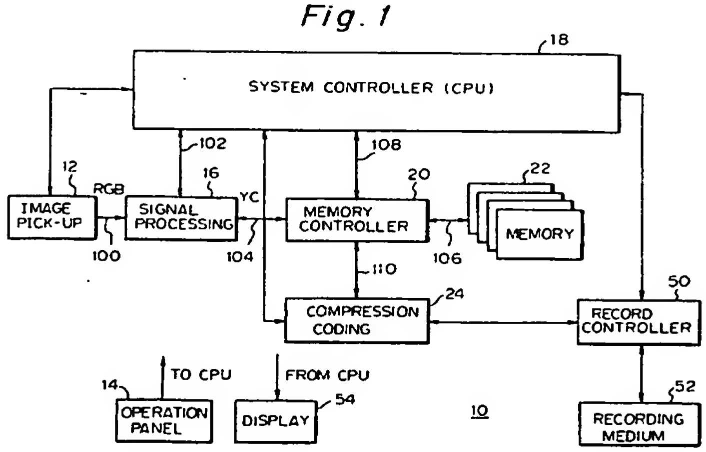
(54) **Method and apparatus for compression coding of color image data and digital camera including the same**

(57) A color image data compression coding apparatus of the present invention includes a signal processing section (16) for processing RGB (Red, Green and Blue) color image data input from an imaging device to thereby output YC (luminance and chrominance) image data consisting of luminance data and chrominance data. When a monochrome mode is set by a system controller (18), the signal processing section (16) fixes the values of chrominance data to zero. The luminance data and fixed chrominance data are written to a frame memory (22) and then sequentially read out of the memory (22) in blocks component by component. A compression coding section (24) codes the image data read out of the memory (22) by use of a JPEG (Joint Photographic Coding Expert Group) system. As for the coded data of the chrominance data, Huffman codes are assigned only to DC components and EOB (End of Block) codes. As a result, an amount of codes produced by subtracting the amount of codes allocated to the chrominance data from a desired total amount of code is entirely allocated to the luminance data as a target amount of code. After the luminance data have been coded in the target amount, the chrominance data are sequentially coded. A method for implementing the apparatus and a digital camera incorporating the apparatus are also disclosed.

Fig. 1



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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 30 2213

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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04-08-2000

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